BUILDING FROM PLANS

Understanding drawings

By David Boddington

WORKING FROM a plan pre-supposes that the modeller will be able to 'read' (understand) the drawing. Also that he will be able to produce a 'kit of parts' by transferring the information on the plan to the raw material and accurately cut and form these items.

Plans must be studied until you understand all parts of the construction and sequence of building. Cross-referring between elevations, plan views and sections should be sufficient to clarify most aspects of the designer's intentions, although there may be some specific recommendations mentioned on the plan, or in the featured article. There are drawing conventions to illustrate types of materials and structural arrangements and some of these are illustrated in this chapter. However, individual draughting styles may not keep strictly to convention and some interpretation may be necessary.

Line thickness variations are normally employed to make the drawing more readable and to give emphasis to complete components. In general, the overall outline of an assembly (say the whole wing or whole fuselage) is always thicker than the rest of the drawing. It

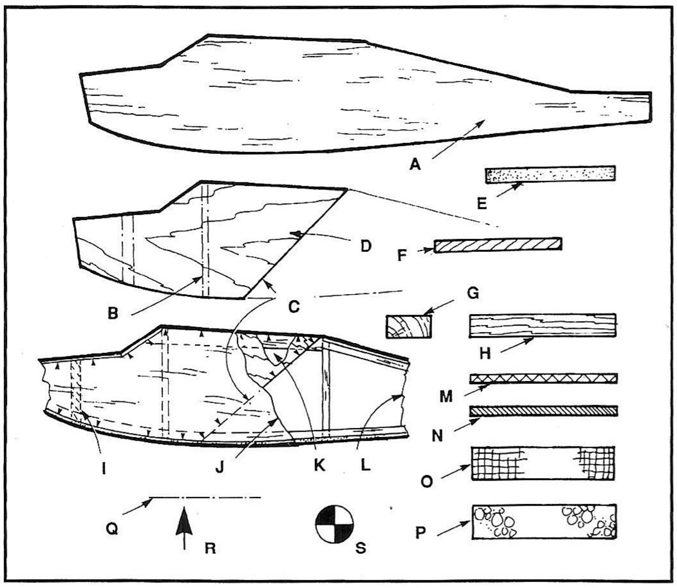


Fig. 1. Above: Drawing Conventions – A. Sheet balsawood. B. Position of former. C. End of doubler. D. Doubler. E. End grain of balsawood. F. End grain of plywood. G. End grain of hardwood. H. Side view of hardwood. I. Position of plywood former. J. Cutaway view. K. Second cutaway view. L. Broken line indicating end of component drawing. M. End view of plastic sheet material. N. Metal. O. Glass fibre cloth. P. Expanded polystyrene material. Q. Chain dotted line. R. Arrow defining limits. S. Balance point (centre of gravity).

indicates that everything within this bold outline is needed for completion. All standard structural components and assemblies are drawn with a medium thickness line. Dotted lines are usually drawn thinner than basic structure lines. Dotted lines have a meaning of their own and will be fully explained in a moment. Finally wood 'grain' is drawn in the thinnest line. Grain pattern and grain direction are particularly important and the designer will have quite definite reasons for the grain going in any specific direction – tangentially across gussets, for instance. Similarly hard woods and plywood are depicted by the 'style' of the lines showing the grain.

Dotted lines have a specific meaning; 'regular' dotted lines on a component or assembly denote that the line is 'hidden' from view – maybe it is behind the component or is internal to an assembly. It is rarely possible to show every possible detail individually and much will be dotted where it lies inside or behind the front face of the assembly. This is the prime importance of dotted lines and one that often leads to confusion.

Secondary uses of dotted lines are manifold and to avoid confusion with the prime use, such lines are often chain, i.e. one long dash and one or two short dots followed by a long dash and so on. This type of line often performs more than one function. One use for the dotted line (Particularly the chain dotted line) is where one wing is drawn reversed on top of the other. This is a useful dodge to save paper and can often be seen on 'free pull-out plans', where space is at a premium.

Dotted lines are often used on parts where two are required but one has additional features, e.g. a wing rib, where one rib is 'whole' and the other rib has cut-outs to clear the internal controls. Often the common rib will be drawn in full, the dotted line showing the cut-outs.

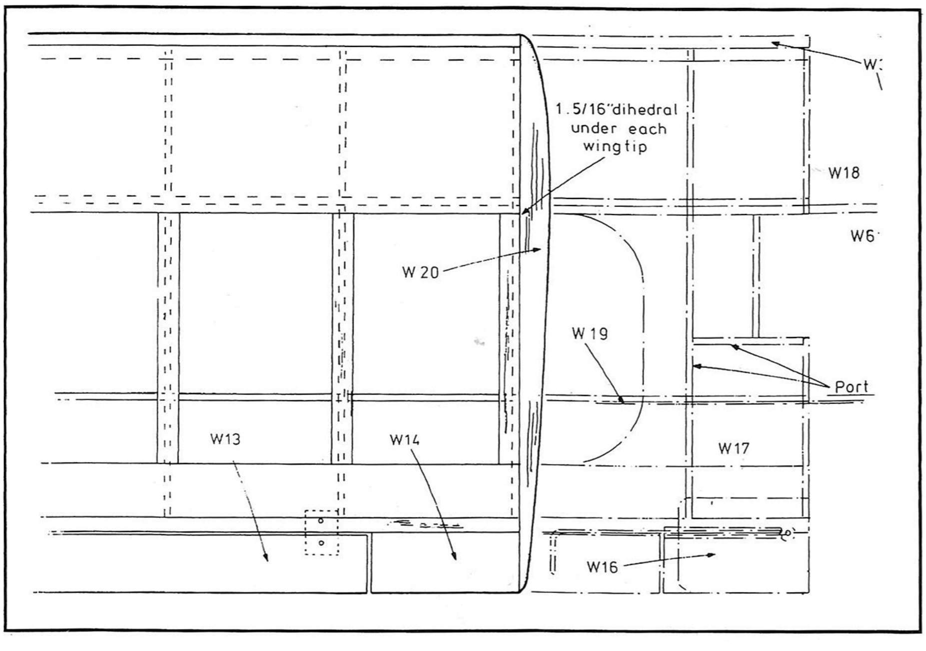
Sometimes it is desirable to show more clearly the internal structure of a given part. This can be achieved in several ways and one common route, say on fuselages, is to draw the side view of the fuselage with the whole side nearest the viewer omitted. This is an acceptable technique for it does make the plethora of dotted lines a great deal easier to read. Of course, one needs to be smart enough to realise that there is another fuselage side and that structurally (i.e. doublers, trebler, etc.) it is of the opposite hand to the one shown. A popular extension to this technique is that of showing one wing half in its entirety, i.e. with all of its outer sheeting in place, and the other wing half with its sheeting omitted, which, hopefully, shows the internal structure more clearly.

An alternative 'cut-away' technique involves showing the external sheet covering over the majority of the structure, but removed from over an area of particular complexity to show the 'insides'. Quite often the area of surface 'cut away' is bounded by heavy lines curved or 'S'-shaped. Occasionally the draughtsman will indulge in a little artistic licence and show the cut away edge oblique – the slanted cut exposing the grain of the wood. These 'cut-aways' are of obvious use by exposing internals to a close study and are diagrammatic only.

Scrap views and cross sections

Because of the complicated assembly of pieces into a structure, the complexity of dotted lines becomes just too confusing to the viewer, even allowing for cut-away sections. To highlight an important structural point either a scrap view or a cross-section may be used. Cross-sections show the structure from a view not normally visible in the average drawing and take the form of a view onto that part of the structure what would be seen if the structure was sawn right through. What the drawing then shows is what you would see on the face of the cut end. This is a widely used technique in many spheres of draughtmanship and

Fig. 2. Below: To save space on the drawing, one wing panel may be superimposed over the other. The second wing panel is usually shown in a chain dotted line.



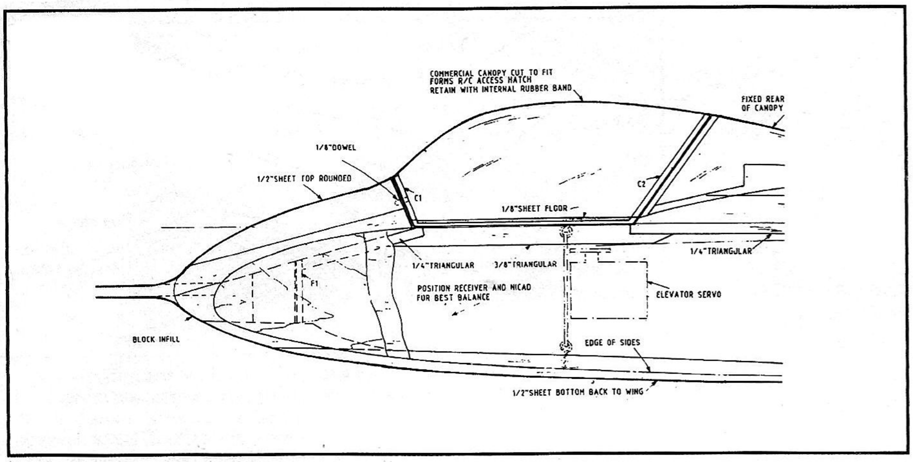


Fig. 3. Above: External sheeting and doublers are often partly shown, terminating in an uneven line, to disclose the internal construction of a fuselage, or other component.

Right-angled arrows either side of the subject labelled A, B, C etc., denote the imaginary 'saw cut' position and the view is the way that the arrows point. Sections are usually captioned – 'Section A-A' or sometimes just 'A-A'.

Scrap views most often consist of just a part of a cross-section, included to explain or expand upon a particular detail. In addition, some draughtsmen will add construction sketches to illustrate assembly. These are usually drawn in perspective and may or may not incorporate cut-aways to show how the parts fit.

In addition to the standard drawing convention there are likely to be some unconventional methods of illustrating components. For instance, piano wire (music wire in U.S. terminology), undercarriage legs shown on the side and front views will not,

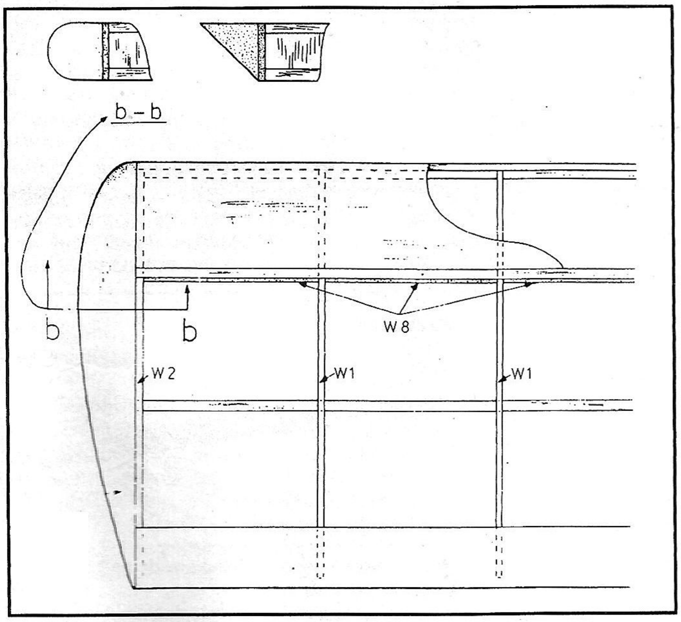


Fig. 4. Above: Plan view of wing showing position of sectional drawing (b-b) with alternative wing tip sections.

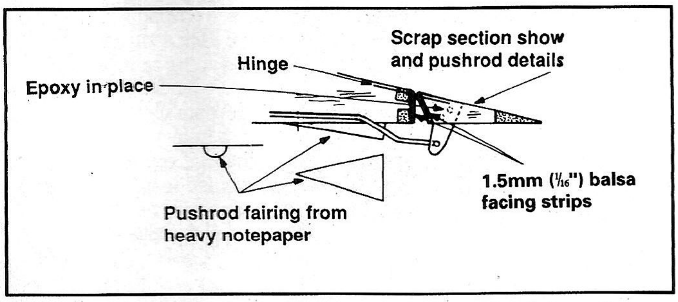


Fig. 5. Above: Scrap view showing the constructional detail, in section, where the aileron forms part of the wing structure.

can be a great help in 'translating' a model drawing. Sometimes this technique is allowed to spill over into other areas. For instance, it is not uncommon for fuselage formers to be shown as though the fuselage has been cut through just in front of the former. It allows the draughtsman to depict not only the 'shape' of the former but also the fuselage top, bottom, sides, doublers, etc., that surround the former, making it patently clear where these other parts fit with reference to the former. It also enables the 'finished' fuselage shape to be shown, particularly important where say, a rounded fuselage contour results from sanding off square corners with 45in stock inside.

Cross-sections can be an immense help in understanding a drawing, once the reader understands them; most cross-section drawings are abbreviated in that self-evident parts are not necessarily identified.

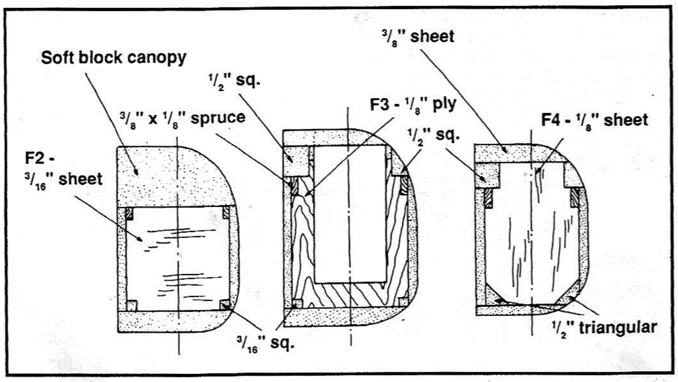


Fig. 6. Above: Fuselage cross sections will often show the basic structure (as on the left half of sections F2, F3 and F4) with the finished shapes after the structure has been planed and sanded to the final shape (right hand halves).

because of the angles of the legs, show the actual length of the component. A separate drawing of the 'true' length and bends of the leg/s is normally shown. Similarly, a dural undercarriage will often be shown 'in the flat' so that the pattern can be used for marking direct onto the material. Bend lines are shown as dotted lines.

Planning the installation of the R/C equipment and linkages is a very definite pre-requisite to building – it will save aggravation and time wasting at a later stage. Most plans will give an indication of R/C equipment deployment, i.e. servos, receiver and batteries, but these must be tailored to suit your own R/C positions, bearers, linkages (whether pushrods, tube and cable or closed-loop systems) battery pack size, receiver and switch – the latter should be clear of the exhaust outlet. The same applies to the engine and fuel tank to be used. Some of the older plans may show redundant forms of R/C equipment, e.g. single channel gear and these must be ignored and installations replanned. You may think that the drawings should indicate modern equipment but think of the tank involved in updating hundreds of drawings every few years to incorporate the latest fashions R/C design! Areas of particular concern with pre-planning are the fuel tank bay (keep it separate from the battery or radio compartments if possible), the battery area (may need lining with foam during construction) and the pushrod linkages (will it be possible to install them after the fuselage is complete?)

Occasionally, a plan will show only one wing half in order to keep the overall size of the print to manageable dimensions. The opposite wing panel may be shown in a chain dotted form overdrawn on the completed wing half but, if not, the plan must be treated so that the drawing can be seen from the reverse side of the paper. Special 'transparentisers' are sold at drawing office suppliers but liquid paraffin (sure to get you going) will also do the job – just rub it on with a wad of cotton wool.

Make a list of the materials you will require to complete the model, remembering to make a note of the grades and type of balsa wood to be used. Judging the quality and grades of balsa will come with experience and they are not always noted on the plans. It is only possible to be approximate in the specification of balsa standards but, in general, they are:

Fuselage sides:	Medium
Doublers:	Medium hard
Top decking (thick sheet):	Soft
Formers:	Medium
Wing ribs:	Medium quarter grain stock
Wing sheeting:	Medium/soft flexible
Spars:	Medium/hard straight grain
Wing tips:	Soft
Sheet tails:	Soft

The model shop proprietor may be able to assist you in selecting grades of wood; it is worth the extra time in careful selection of wood particularly where 'matched pairs' are required, i.e. fuselage sides, wing sheeting, trailing edges, etc. You may be lucky in finding sheeting that is cut from the same log (matching sheets are usually every other sheet from the pile) and these can be identified by having near identical grain patterns. Purchase all of the other items you will require, such as engine mount (check the crankcase spacing first), fuel tank (to fit the available space), nose leg (correct height from the former to wheel axle), spinner, canopy, hardwood, piano wire, horns, clevises, saddles and son. Making a comprehensive list of materials may be a little time-consuming initially but it will save many return trips to the model shop or, if you are miles from civilisation, frustrating waits for mail order deliveries.

Making your own kit

DRAWINGS THAT have been folded for a lengthy period can have fold creases that are a nuisance when it comes to drawing out the components, and during construction; these can be partially removed by ironing the print on a table overlaid with sheets of newspaper.

Having achieved a flat drawing we now have the job of transferring the shapes of components, wing-ribs, formers, tail surfaces, etc., to the materials to be used. Of the methods described here, no single method is the ideal for all purposes and the considerations of time and expense will probably become the deciding factors for selection. Accuracy, in the marking out and cutting, is all-important. Incorrectly shaped parts will make construction difficult and will almost certainly result in a model that is twisted or wrapped. For this reason, a kit that contains inaccurate parts is more of a liability that an aid, but at least you have someone to blame; cutting out the parts yourself leaves only one person responsible – providing the plan is correct.

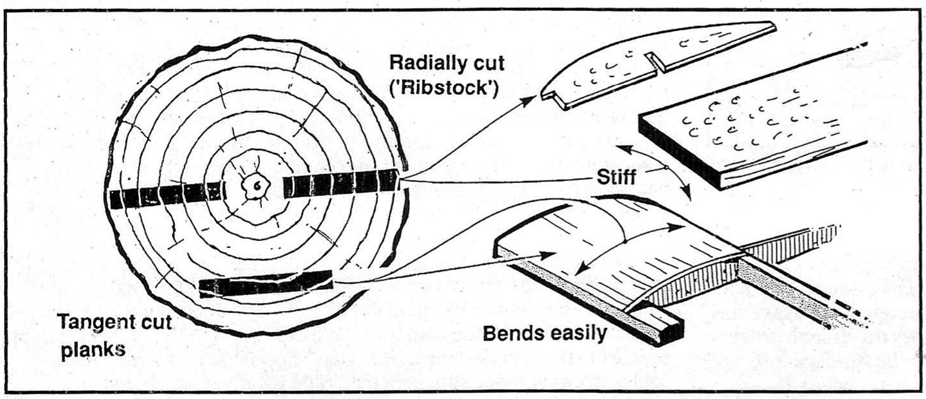


Fig. 6. Above: How the sheets are cut from the log will determine the qualities of the balsawood.

Materials

The Majority of the structural components of models featured as plans use 'traditional' materials, i.e. wood and wire. Although the use of plastics, in the form of GRP mouldings, vacuum formed items and veneer covered expanded polystyrene foam components, is becoming

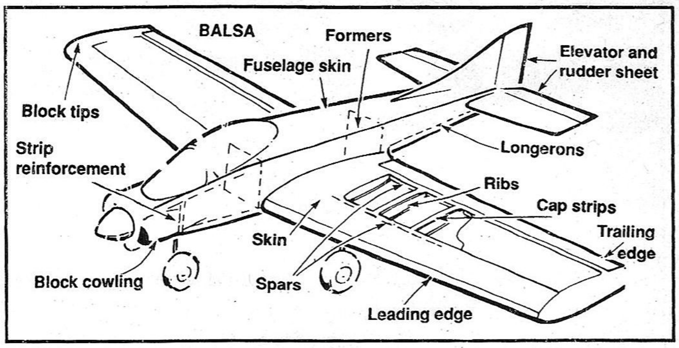


Fig. 7. Above: Selecting the correct grades of wood for the purpose is important to give a maximum efficiency (weight/strength) airframe.

increasingly popular in kits they are employed to a much lesser degree with plan subjects. Where, for instance, a moulded cowl, transparent cockpit canopy or veneered foam wing IS required there will often be a special offer for these items from the company selling the plan.

One distinct advantage of building from plans is in being able to select one's own wood. Selection of balsa may, in the first instances, seem to be a frightening prospect due to inexperience. Fortunately, the good model shop proprietor will help the newcomer to make a sensible selection and from continued experience the modeller will gain knowledge. Alternatively, you can buy balsa in bulk from one of the excellent mail order suppliers (or from one of the many trade shows) and learn to select wood for the various purposes.

Strip wood is better cut yourself from sheet than bought as individual sticks in shops. Because of the widely varying nature of balsa, it is likely that there will be no similarity in strength, weight and hardness in a dozen pieces of strip bought at random. The effect of building a strip wood fuselage (whether a square box trainer or a fully

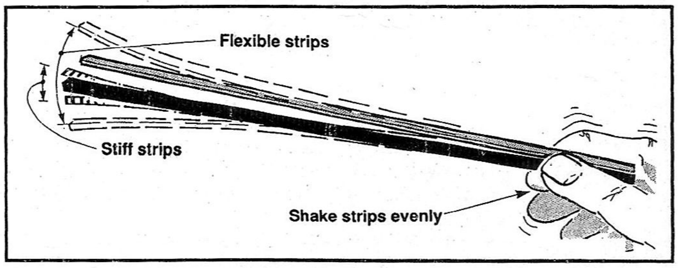


Fig. 8. Above: To select strips of equal quality, shake evenly and choose

stringered vintage job) from dissimilar strip will be a twisted structure. The practical step is to take a sheet of wood of the appropriate strength and thickness and cut it down as needed. This will ensure a much closer match of the wood quality from strip to strip. Even here one can easily fall foul of the system, for as often as not, any given sheet will vary in strength and weight from one end to another. Try marking right across one end of the sheet with broad felt tip pen before stripping it down. Once cut, it becomes easy to identify one end of each strip and construction should have all of the marked ends at the same end of the structure.

Cutting sheet into strip with accuracy and repeatability is possible if care is taken. A sharp knife and a steel straight edge is enough if you are careful. However, the knife must be held absolutely upright or a slant edge will result.

The use of proprietary balsa strippers is to encourage (there are several brands on the market) or if you are into modern power tools, the current crop of small circular saws provides the professional answer. Either way, a quick pass over with a glass paper block prior to assembling the strip wood helps to achieve a higher standard of modelling.

Sheet wood parts are a different story. Once more the right grade of wood is of importance and so is the grain. The grain direction is often important to the strength of the part itself and to the completed structure. Therefore, if the plan shows the grain in a given direction, accept that the designer knows his business and make sure that the grain is in the right direction on your cut part. This means that you have to mark out the part correctly in the beginning!

Most other materials – spruce, plywood, beech, Paxolin (a touch material composed of compressed resin-impregnated cloth), piano wire, etc – have a much more consistent quality and the same degree of

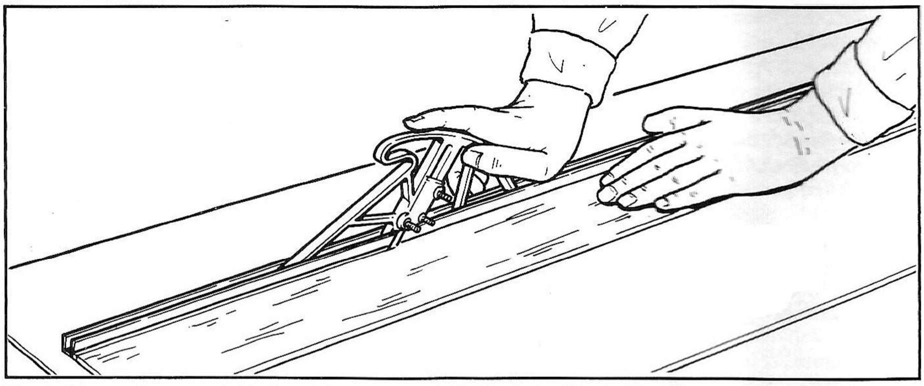


Fig. 9. Above: Commercial balsa strippers are available and will provide a clean straight cut for strip sections from sheet balsawood.

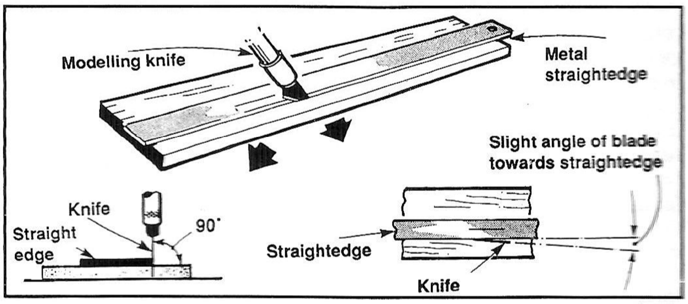


Fig. 10. Above: An alternative to using a commercial balsa stripper is to cut with a modelling knife, with a straight edge as a guide. The knife must be kept vertical (when viewed from behind) and the straight edge held

selection is not required.

Transferring the pattern

Getting the pattern transferred to the wood in the first place (so that you can then cut it out) is the first move and, as always, there is more than one accepted method. Traditionalists trace the part in question onto tracing paper using a pencil or ballpoint pen (the older type of pens are probably best for they leave a 'wet' ink line). Turning this tracing over and noting the grain, draw over the back of the outline and the pencil line or ink will be transferred onto the wood. Be careful with very soft balsa, for too heavy a hand with the pen will badly squash the wood.

There are, however, other more convenient methods that have been proven by modellers building from plans.

(1) Carbon copying

By placing a sheet of carbon paper – the pencil variety, not typewriter carbon paper – between the plan and the material, the outline of the component is transferred by overdrawing on the plan. Check that the material is in the right position by 'feeling through' the plan. The material and plan should then be secured with pins to prevent any movement during the tracing procedure – it can be highly frustrating to be three-quarters of the way through carbon tracing a complex item only to have the plan move slightly, for it then becomes impossible to realign the work. Because wood is a natural material and has soft and hard areas and is not perfectly smooth, it is not easy to keep smoothly to the line to be copied. The use of a ruler and French curves will make the tracing operation easier as they give a firmer support for the pencil (use an HB or F grade and keep it reasonably sharpened). Carbon paper can also be used for producing reverse images on the rear side of the drawing – simply place the carbon face up – useful when only one half of a wing plan is shown. Fastidious modellers may prefer to trace the component first on to tracing paper before transferring by carbon paper, to the material; this has the disadvantage of increasing the chance of drawing errors.

(2) 'Pinning Through'

Position the material under the plan, hold it securely, and prick with s pin through the outline on the drawing onto the material. This method is acceptable for balsa and plywood but, obviously, is not suited to materials such as Paxolin and sheet metal. The spacing of the pinholes will vary according to the curvature of the line – the sharper the curvature the smaller the pitch of the holes. Whether the 'pinned' outline is then drawn with a ballpoint pen on the material will depend on your ability to cut accurately without further guidance. Straight lines only require pin hole reference at the extremities of the line, when the cut can be made using a steel straight edge and knife or the line inked-in for cutting with a saw (see Fig 4.5).

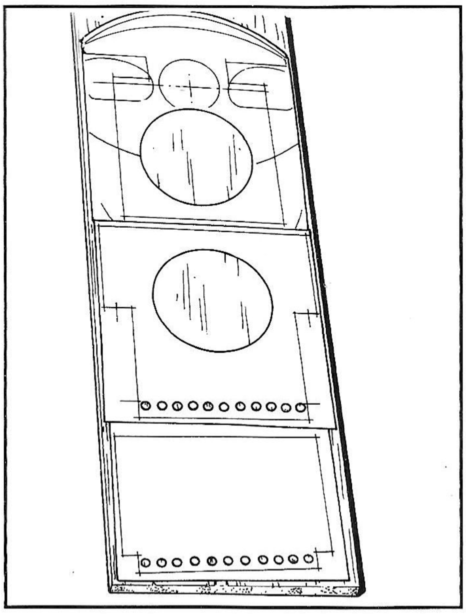


Fig. 11. Above: Photocopies from the plan can be glued – using Cow Gum – to the material in preparation for cutting and drilling. The paper also assists in preventing splitting of the material as it is cut, it is easily removed and the gum cleaned off the surface.

(3) 'Pasting'

Providing you can afford the expense of having more than one copy of a plan, the majority of the components can be transferred by cutting them out and sticking them to the material. Cow Gum is the ideal adhesive (described later) for this purpose as it is compatible with most materials. Where materials such as Paxolin make the previous methods impossible, use of the pasting-on system is a good alternative, even if it entails using a carbon copy rather than the original. For intricate and delicate balsa wood components it has the further advantage of reinforcing the wood during the cutting operation.

(4) Photocopying

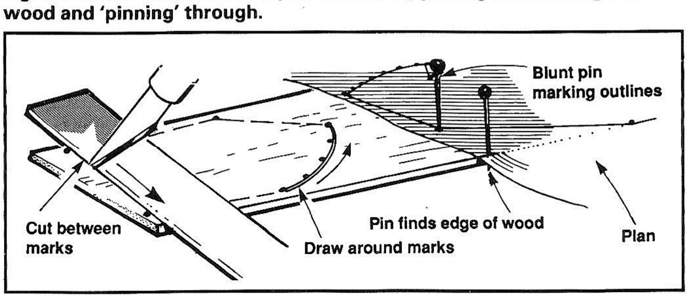
Access to a modern photocopier is necessary for this procedure but, fortunately, most major libraries now have this facility and companies offering 'instant print' service are to be found in even the smallest towns. The method is well illustrated in the accompanying photographs and the only equipment that is required is a domestic iron, or one of the thermostatically controlled irons used for heat shrink film; a higher temperature than used for covering film is necessary. Some increase of image size is possible during the photocopying procedure but this is so small s to be of no consequence for normal size components. (Note: dye-line prints also tend to expand and contract according to temperature and humidity conditions). Because of the expense involved, it is not suggested that photocopying should be used for transferring all components – there are also size limitations – but it is an excellent method of the more complicated items, e.g. fuselage formers with curved sides and numerous stringer notches.

Cutting Out

Gone are the days when you could build a model with the use of only a broken razor blade, some pins and a tube of balsa cement – if they ever existed. For good results, satisfaction and release from frustration, having the correct, good quality tools is essential. A sensible minimum of tools should include the following:

(a) Knives
Swann Morton No.5 handle, No.11 blade (or X-Acto equivalents).
Swann Morton No.4 handle, No.10A & 24 blades.
Stanley knife, standard blade.

Fig. 12. Below: Balsawood may be marked by placing the drawing over the wood and 'pinning' through.



(b) Saws
X-Acto Razor Saw, 1/2in. deep.
Fretsaw – hand, treadle or electric.
Hacksaw – high speed blade.
(c) Plane
Razor plane – heavy duty blades
(d) Straight-edge
Steel ruler plus longer piece of straight aluminium stock (say 1/8 x 5/8in).

Swann Morton knives are good with high quality blades – no doubt there are suitable equivalents and alternatives commercially available. The small blades knife (No.5) is a must for the intricate work but, due to the flexibility of the blade, is less good for cutting heavier grades of wood.

For thicker, or tougher, woods, the Stanley type knife is more suitable but the blade quality is not to the same standard as the surgical style Swann Morton knives and loses its edge more rapidly. Being a bulkier blade it is also more limited in the radius of cut that can be performed. Many modellers seem to assume that when a blade has become blunted it is of no further use, but there is no reason why the blades should not be resharpened – it only requires a few strokes on an oil stone!

Fretsaws are available from a few pounds (or dollars) or so, to around a hundred pounds ($180) for the more exotic electric versions.

A good quality triangular ('three-square') file is desirable for cutting piano (music) wire.

Razor planes are mostly used for shaping block areas, leading and trailing edges, tail surfaces, etc. For these purposes a razor plane is virtually indispensable – how did we cope before it was invented?

Straight edges, in the form of steel rules etc, should always be used when cutting a straight part of a sheet component; the longer straight-edge (3 foot minimum) is used, for instance, for trimming the edges of a sheet of balsa – never assume that it is straight.

What tools to use for cutting the various materials will be found by experience but here are a few guidelines to types and methods.

Small strip
Up to 3/16in sq. Use a medium size knife.

Larger strip and hardwood strip
Use the razor saw, rotate the strip so that equal cuts are given on each of the surfaces to ensure a square cut. Soft and medium grade balsa wood may be cut with a heavy duty knife using the same method.

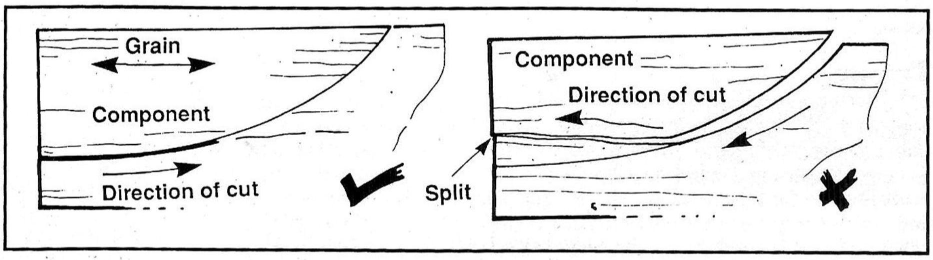
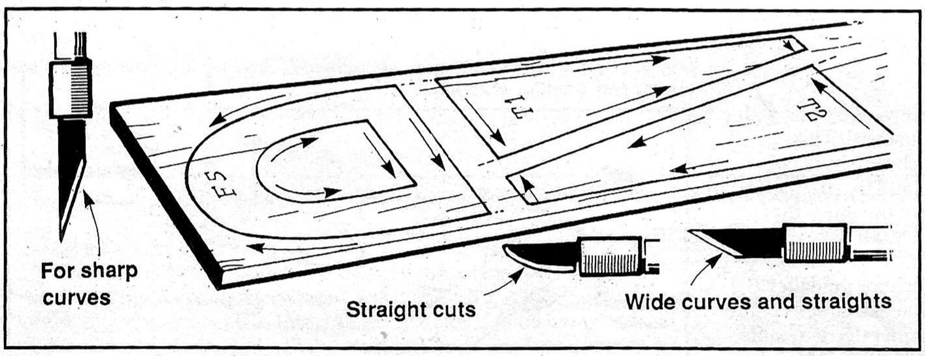


Fig. 14. Above: The right and wrong directions of cutting a curve in balsa sheet.

Thin sheet balsa
Up to 1/8in medium grade. A small knife is satisfactory for the curved areas (watch out for the blade flexing and giving an angled cut) but the larger knife can be used for straight or lightly curved lines. Where a component has an interior cut-out this should be cut first, but not removed, to retain the overall strength. Make the first incision light – do not try to cut the material in one operation but gradually increase the strength of the cut when the accuracy of the line is assured. Cut on to a piece of 'K' quality hardboard, or similar surface, and when you think you have cut through completely, check on the reverse side to confirm that this is so. Internal corners are the most frequently missed area and the component should never be forced out by breaking the wood fibres. Very small radii curves are difficult to cut with a smooth cutting action and may have to be cut by 'jabbing' the knife blade through the material at close intervals; it will be necessary to assist the cut from the reverse side. As you proceed to cut a line, look ahead of the point of the knife and not at it; this will lead to a more accurate and smoothly performed cut. Delicate work can be protected by the application of a clear cellulose adhesive tape (Sellotape or Scotch tape), the tape being carefully removed afterwards. Cyano-acrylate adhesive applied to suspect or naturally weak areas will strengthen them considerably.

Fig. 13. Below: Cut the wood in directions indicated to reduce risk of accidentally cutting the part.



Thicker balsa sheet and plywood
Plywood up to and including 1.5mm (1/16in) can be cut with a heavy duty knife provided, with the thicker grades, that the curves are not too sharp. The same applies to balsa up to a quarter inch thick, but above this, and with hard balsa, a fretsaw must be employed. When using a straight-edge, for a straight cut, position it so that it covers the component being cut; if the knife blade does wander it will then cut into the waste area and not into the component (Fig. 4.5). Where possible cut away from the grain of the wood to prevent the knife from 'digging-in'. (Fig. 4.7). Because it is easier to cut towards yourself the work must be constantly moved around to achieve this – not easy with a large section of material and limited cutting area. Keep the material size to a reasonable minimum, leaving enough spare to conveniently hold, but not so much surplus that it gets in the way.

Fretsawing with a hand fretsaw is not the difficult operation that many modellers make it appear. Keep the rhythm of the saw strokes constant, the saw upright and move the material to the saw. You do not go round corners by turning the saw (it's impossible with a power fretsaw so why attempt it with a hand one?) Normally a sawcut will give a smooth edge on one side of the cut and a relatively rough edge on the opposite side – keep the smooth edge to the work side. If the undersurfaces of the material is cut too rough and 'woolly' apply adhesive tape before cutting. Again it is most important to look at the line ahead of the actual point of cut: for straight or slightly curved lines you can look fairly well ahead, for more acutely curved lines, just ahead. The reasons for this technique may not be immediately obvious, until you consider that the materials must be 'fed' into the saw blade. Looking directly at the blades gives no indication of the actual direction that it must be moved (when you are riding a bicycle you don't look at the wheel to steer!). The same principles apply to virtually all cutting – knife, saw, scissors – irrespective of whether the material or the tool does the moving and yet it seems to be one of the hardest lessons to learn, probably because of the far of not actually being able to see the precise point of the cut. Have fait, the results will justify the means.

Despite taking great care there are bound to be some inaccuracies and these should be corrected, usually with a sanding block, immediately the part has been cut out; if you leave it until later you will probably forget about.

Hacksaws are mostly used for cutting metal but can also be used for straight cuts on heavier sections of hardwood. The material to be cut should always be supported in a vice and remember that the cutting stroke is the forward motion (providing the blade has been inserted correctly). Cutting metal tube can be tricky, unless a regular and rhythmic action is maintained, particularly as the saw blade penetrates the tube wall initially. Smaller sizes of tube may be cut by scoring the surface, with a rolling action of a knife blade around the circumference, and breaking the section of tube free. Piano or music wire may also be cut with a triangular section file, rotating the material in the vice between cuts.

Cutting block wood, or shaping strip, with a razor plane is not difficult providing you do not have to cut against the grain. It is not always possible to tell from the appearance of the wood in which direction the plane will tend to 'dig in' and which will give a smooth cut – test the wood gently until you have established the correct direction. Purchase a razor plane that gives some adjustment of blade depth of cut as the setting will vary according to the material being planed. Heavy duty blades are available for the planes, as domestic razor blades are only suitable for soft grades of balsa.

Some modellers prefer to cut out all parts before they commence construction of the model. This is the quickest way in the long run, but can be a little tedious – at a minimum you

should aim to cut out all of the components for one structural unit – i.e. wings or fuselage. Check the parts against the plan for accuracy and if you have made a mistake replace the faulty part.

Construction

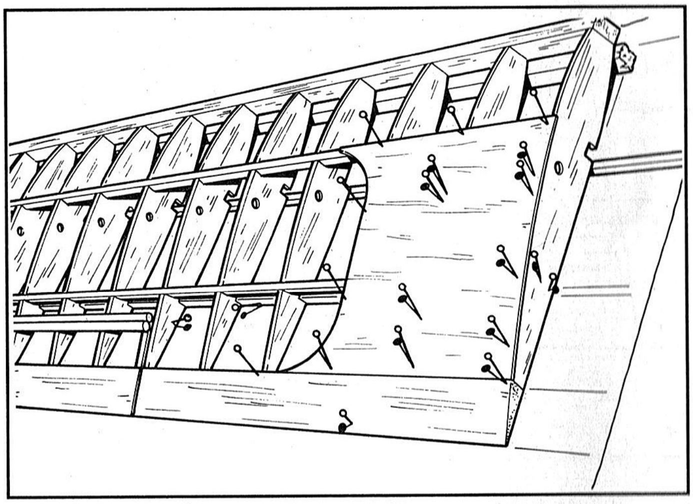


Fig. 15. Above: Building a bi-convex (curved on the top and bottom surfaces) requires the wing ribs, spar and leading edge to be supported by 'spacers' on the building board.

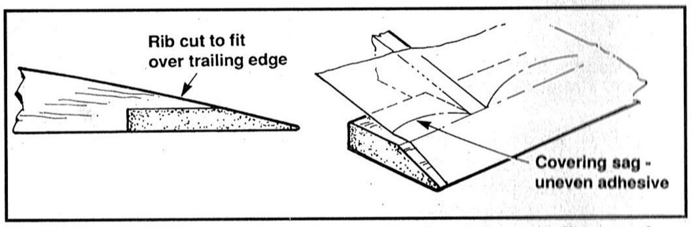


Fig. 16. Above: With a strip trailing edge, the covering may adhere to the top surface.

CONSTRUCTION, IN the context of this book, deals with conventional forms of building and not GRP and foam methods. As few models are built 'in the hands' our first requirement is a building board and this must be both flat and capable of accepting and supporting pins. Old fashioned softwood drawing boards make excellent building boards, providing you can obtain a large one at a reasonable cost. One of the best building boards can be produced by contact glueing a sheet of 'K' quality hardboard (as used for pin-boards in schools – to a slab of marble, recovering from an old wash stand – a flat, level surface is ensured. A good substitute is to purchase a flush door panel – the heavier the construction, the better – support it adequately as a bench top and cover it once again with pin-board material. Where working from the kitchen table is unavoidable a portable building board can be a softwood drawing board or be constructed from blockboard or chipboard; it may be necessary to screw some battens to the underside to prevent warping.

Building pins aren't what they used to be! Once upon a time it was possible to buy high quality glass-headed pins (usually of German manufacture) that had glued steel shanks and very secure glass heads. Modern equivalents seem either to have plastic heads, soft shanks or glass heads that readily pull off or shatter.

Alternatives to the glass headed variety are steel 'T' pins, and these are preferable to sub-standard examples of the other types. They are available in two sizes, the smaller ones being ideal for pinning sheet areas and strip in position and the larger variety for 'supporting' components on the plan as opposed to pinning through material.

Starting point

Clear the building board of any dust and small pieces of debris and tape down the plan, stretching across the diagonals. Much of the construction of the model will be directly over the plan and, to prevent it from being damaged from parts sticking to the plan, the surface must be protected. Thin, clear, polythene film makes an excellent barrier, as few glues will adhere to this material and the drawing is not obscured. Dry soap, or a candle, can be rubbed over all of the areas likely to be affected by glue, but it is easy to miss some parts unless you work logically.

Accuracy of cutting components was emphasised in the last section and the same applies to the cutting of longerons, uprights, spars, etc. Cut them precisely to length, including angles for dihedral, before pinning down. Trimming at a later stage is a more difficult operation. Some prefinishing can also be undertaken at this stage, by sanding surfaces that will eventually be exposed, e.g. fuselage sides, longerons and spars.

Wings

Modellers often commence construction of the model with the wings and tail surfaces, leaving the more interesting work on the fuselage until last. Flat bottom section wings with a single 'V' dihedral are the easiest to build as the lower spars and trailing edge can be pinned directly onto the building board. Semi-symmetrical and symmetrical sections will need the trailing edge and leading edge packed up from the board with scrap pieces of balsa wood – you must ensure that the packing is all of the correct height. The plan may call for 'wash-out' to be incorporated

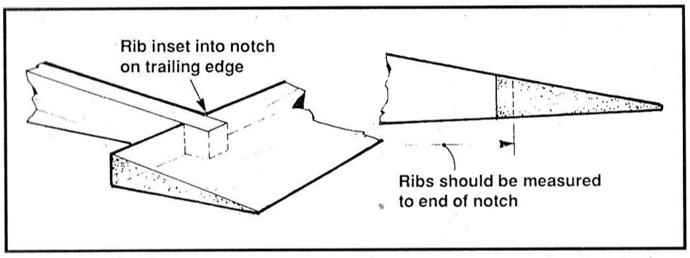


Fig. 17. Above: When a sectioned trailing edge is used the ribs should be slotted into the balsawood.

during the construction of the wing. Wash-out is the progressive reduction of incidence of the wing towards the tip, i.e. the trailing edge of the outer wing panel gradually rises in relation to the leading edge to help eliminate the risk of tip stalling of the model during slow flight manoeuvres. It is important to incorporate this stability feature at the construction stage, since trying to induce it during covering may weaken the structure or prove to be only temporary in effect. Ideally, a tapered 'wedge' of balsa wood should be positioned, spanwise, under the trailing edge to achieve a constant change of incidence.

Three types of trailing edge construction are commonly used: a single lower trailing edge member, a sectioned solid member or sheeted top and bottom, with vertical webbing on large models (See Fig. 6.3).

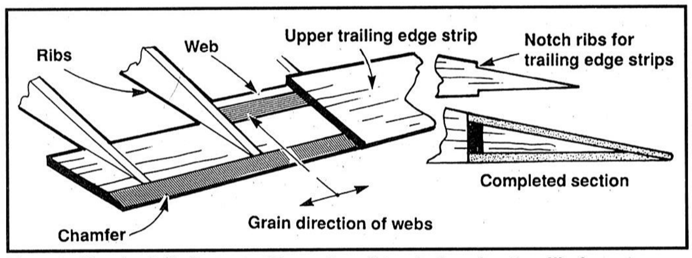
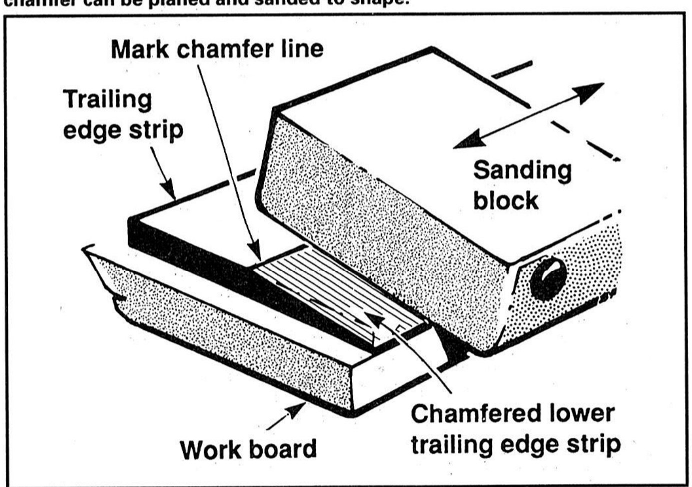


Fig. 18. Above: A built-up trailing edge, from balsa sheet, will give a strong, light structure.

Trailing edge section balsa wood may not always be readily available in the size specified, but it is easy to form from standard strip using a razor

Fig. 19. Below: Where suitable trailing edge stock cannot be used, the chamfer can be planed and sanded to shape.



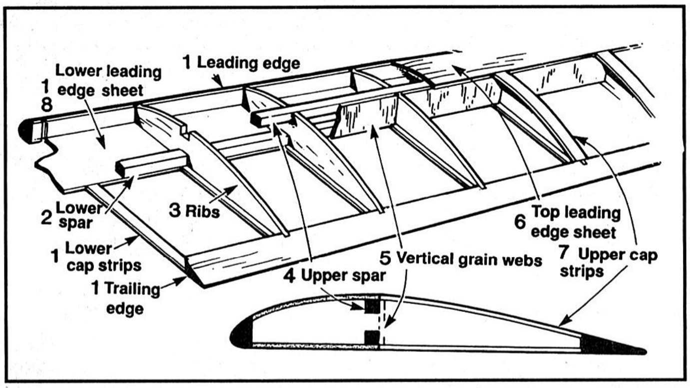


Fig. 20. Above: For medium sized models the above framework results in a tough, rigid structure which will resist warping when covered.

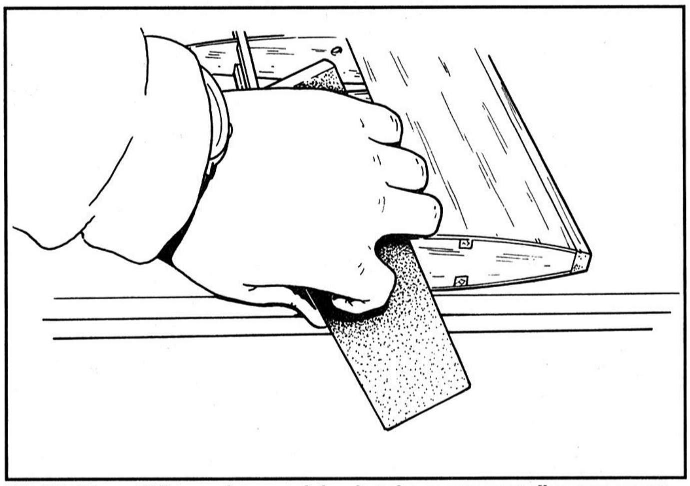


Fig. 21. Above: Where wings are joined at the centre root ribs, care must be taken to achieve the correct dihedral angle and to sand the root ribs level.

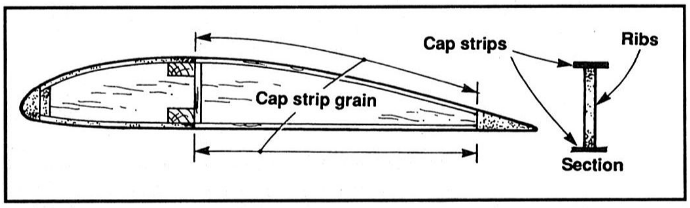


Fig. 22. Above: Gluing cap strips to wing ribs is following good full-size practice and it produces a strong 'I' section.

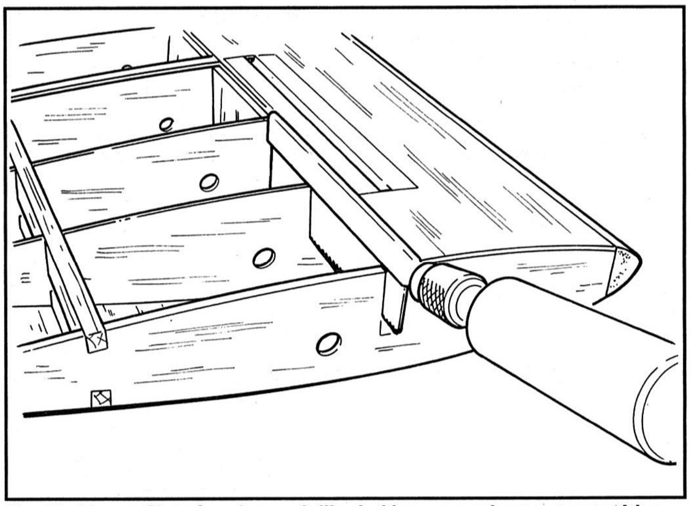
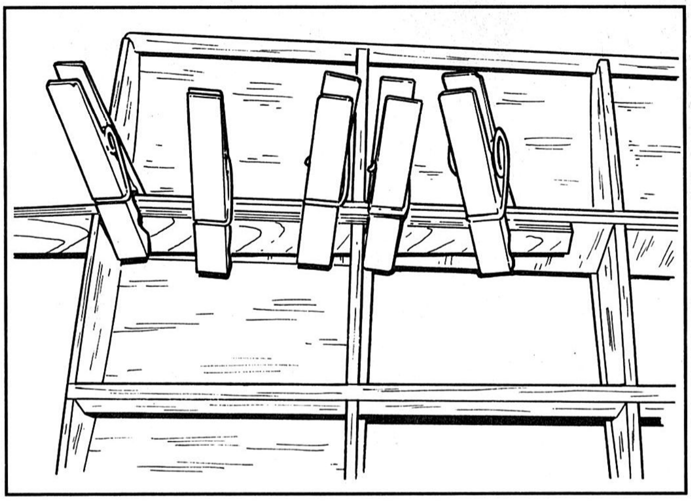


Fig. 23. Above: Slots for plywood dihedral braces are best cut out with a deep-bladed razor saw. Mark the width and depth of the slots before cutting.

plane and sanding block. Plane away as much of the surplus wood as you can safely achieve, then hold the wood on the edge of the board and sand to the section required. With this solid trailing edge it is usual to cut slots for the ribs to slot into; make sure the ribs are deep enough for the trailing edge – it is easier to sand away the ribs than to sand the whole length of the trailing edge on the assembled wing. Spars must never be too tight a fit into the rib cut-outs, as forcing them in will result in split ribs and an absence of glue in the joining surfaces, plus a greater risk of the wing warping. No part of the wing should be constructed with inherent stresses in the components; if you have to force any of the



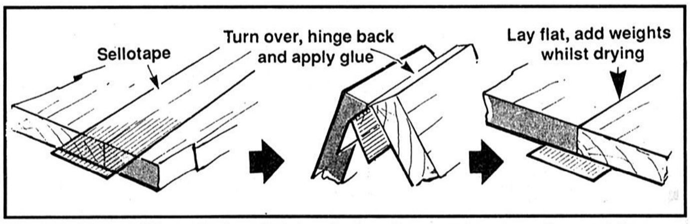


Fig. 25. Above: Note: Before joining balsa sheets trim the edges with a knife and straight edge.

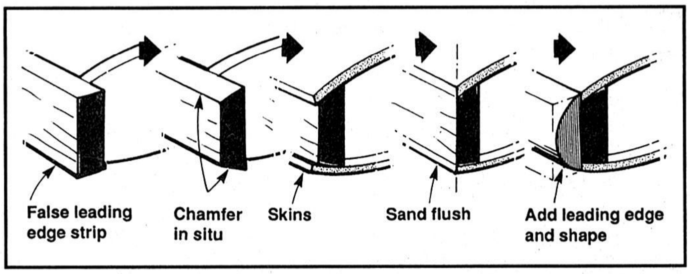
parts, check where the error has occurred – it may be warped strip wood – and correct it before final glueing.

Wing construction, in trainer and sports models, will normally feature a sheeted forward section. In some cases, the lower surfaces cannot be sheeted until the structure has been removed from the building board, but as much of the construction as possible should be completed at the pinned down stage. We need the structure to be as rigid as possible when it is removed from the board; for this reason also, leave the structure pinned down overnight to allow the glue to reach maximum strength.

Root ribs must be angled to cater for the dihedral angle when the panels are joined, and a template should be cut to check the angle against the building board. PVA adhesive can be used for all wing construction and it gives ample time for fitting sheeted areas, but wipe away any surplus glue that gets onto the surface. Where sheet has to be joined, lengthwise, for large sheeted areas, the edges must be trimmed with a straight-edge and can then be glued together as shown in Fig. 6.7. Sheeting up to a full depth leading edge will probably require the sheeting edge to be chamfered, see Fig.6.7), and this is achieved by judicious use of a razor plane. Large leading edge sections have to be sectioned carefully, and this will be made easier by drawing a centre guide line down the length of the leading edge and making a template of the profile.

Joining wing panels must be undertaken with precision to obtain the correct dihedral angle and to avoid any twists being incorporated. Cut slots for the dihedral braces with a razor saw and check that the brace will fit snugly into the slot to the full depth require. Dry-fit the braces and wing panels together to check the close mating of the root ribs and trim the ribs if necessary. Ribs must not be forced together where the

Fig. 26. Below: Fitting a false leading edge makes fitting the balsa skins easier, neater and stronger.



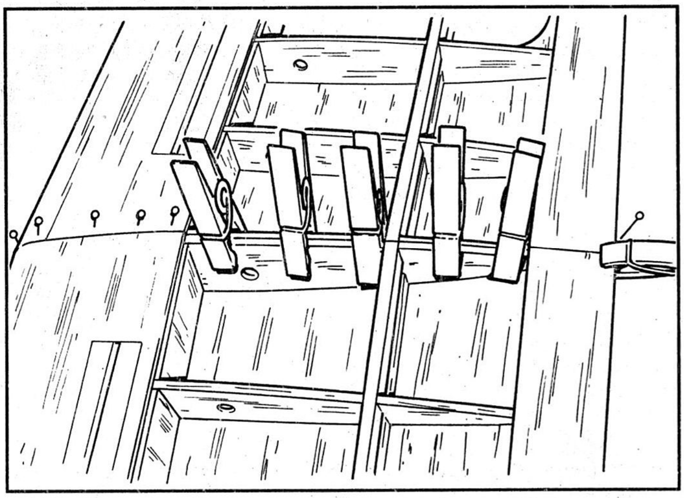


Fig. 27. Above: Glue the dihedral brace to one wing panel first, ensuring that the brace is held firmly against the wing span and infill.

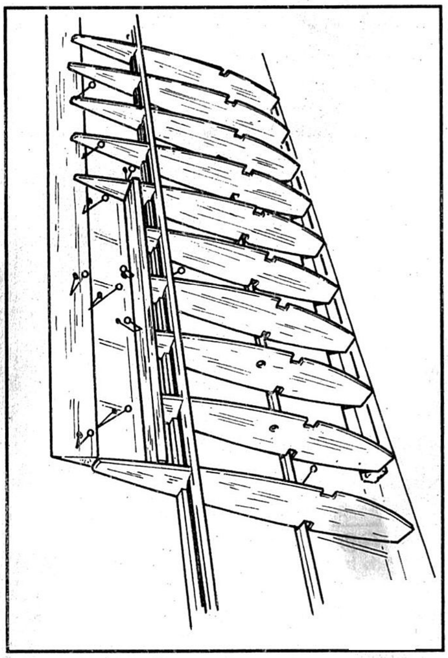


Fig. 28. Above: The first part of the wing structure where the aileron is being built integral with the wing.

initial construction is at fault, or undesirable stresses will be induced. Small gaps may be filled by using epoxy adhesive for joining the panels.

When you are satisfied with the fit of the wing panels, glue them together and pin to the board, with blocks under the wingtips to give the correct dihedral angle, the blocks parallel t the wing chord unless wash-out is incorporated. Clothes pegs will assist in holding the root tibs together and pins and masking tape can also be used.

Aileron fittings

Ailerons, where fitted, can be either inset or strip type. The latter are fitted after the wing construction is complete and only provision for the aileron servo must be made in the basic wing construction. Inset ailerons are operated by internal linkages with pushrods and bellcranks. These must be incorporated as the wing

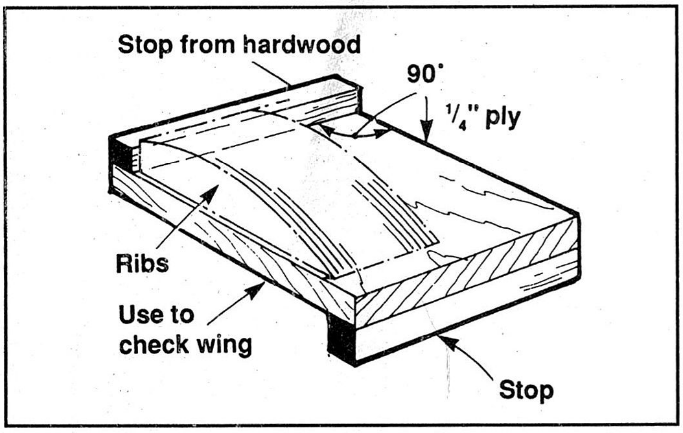


Fig. 29. Above: Ribs can be checked for identical size by placing them together.

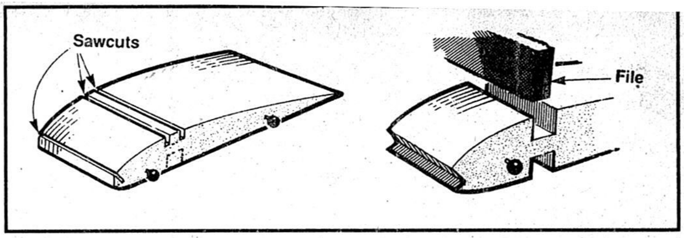


Fig. 30. Above: Notches are cut in multiple rib blocks with a razor saw or filled with a flat file.

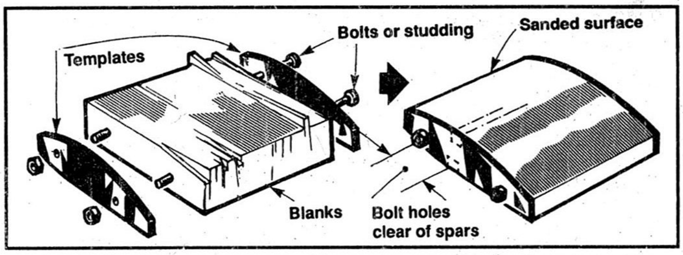


Fig. 31. Above: Where a larger number of identical ribs are required the 'sandwich' method is to be preferred.

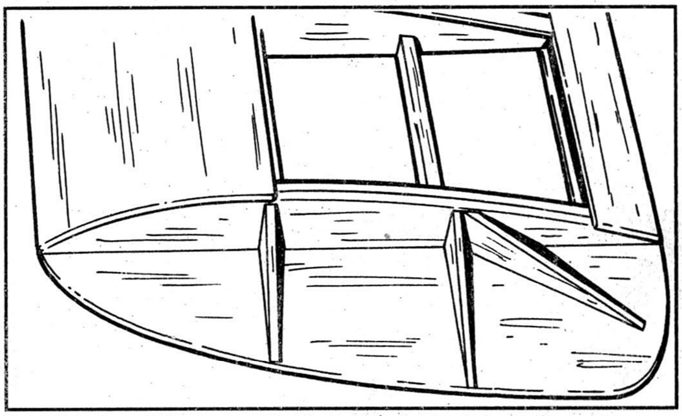
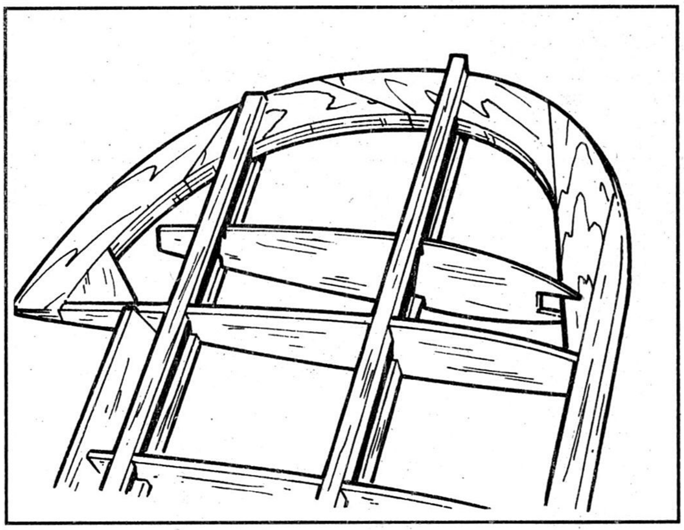
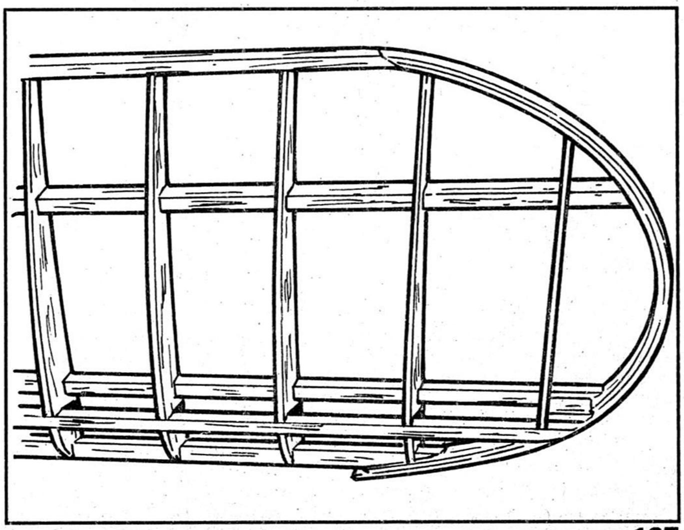


Fig. 32. Below: Wing tips may be formed from sheet, built-up sheet sections or from an outline formed of alternate thin plywood (.8mm) and balsawood laminations. The latter offers the lightest form and can be quite strong enough.





construction proceeds, performing holes for pushrods and building in supports for the aileron bellcrank. The drawings should indicate whether the ailerons are built integral with the wing and cut out afterwards or constructed as separate items. Remember to leave sufficient clearance between the aileron and wing ribs, as the covering adds a slight thickness.

Tips

Shaping identical, built up, wing tips is simplified by producing a thick cardboard or plywood template to the outline of the tip. This can be used for marking and checking the shape of the tips and is even more useful if you are building a multi-wing model.

Fuselages

Fuselage construction can be of two types, or a combination of them – sheeted or open structure. The open framework construction seems to be out of fashion these days, probably because sheeted construction is rather more rapid and straightforward. It is wrong to assume that open structures are too weak to be useful for R/C work, for in some respects they can result in stronger assemblies as they can take shock loads by flexing, whereas a sheeted structure would split. They do, however, require accurate building with close-tolerance joints between longerons, uprights, crosspieces and diagonals. This form of structure also benefits from the added strength given by covering in nylon. Perhaps the wheel will turn full circle and open framework structures, with sensible use of gussets, plywood reinforcing and sheet infill, will make a return. For a maximum strength/weight radio structure there is nothing to beat this form of construction when properly designed and it is a good exercise in building techniques. It is customary to build both the fuselage sides together, one over the other, separated by plastic film, to ensure that the outlines are identical – all spacers are cut in pairs. Select the longerons for the sides for similarity in density and 'bendability' to give an equal curvature of the sides when they are drawn together at the tail end.

Fully sheeted fuselages have less work content and are easier to assemble than the open structure variety. They offer less flexibility in the weight distribution throughout the length of the fuselage, i.e. the rear end tends to be heavier than is ideal, but this is compensated for in the design of the model. The completed structure is very rigid and is suitable for heat-shrink film although nylon or heavyweight tissue will add further strength to the fuselage. Plastic film covering is often applied by sealing only the edges of the film and heat shrinking the intermediate area with a heat gun. This will give an attractive smooth finish but adds no strength whatsoever. By ironing the film over the whole of the sheeted area and thoroughly bonding the film adhesive to the balsa wood, a greater resistance to splitting is achieved. The most likely damage to a rigid box fuselage structure is caused by the shock load of a crash (nose dive into the ground) transmitting stresses down the fuselage and splitting it open.

Local reinforcement, around the nose, wing, seating, undercarriage fixing and tailplane position is provided by glueing doublers to the basic fuselage sides. To work efficiently, these doublers must be completely bonded to the sheet and the adhesive should be evenly spread with the doubler secured over the whole of its surface area. Contact adhesive will provide these conditions, but PVA glue may be used on smaller areas, providing it is well pinned or weighted down until completely dried. Any adhesive that relies on natural evaporation for setting, as opposed to a chemical reaction, is obviously going to take much longer to dry out when there is little air present, and it may take 24 hours for the set to occur for an adhesive that normally only takes two or three hours.

Formers and bulkheads may be keyed into the fuselage side structure between the doublers. This provides automatic location of them during assembly. Use the formers and bulkheads as temporary positioners for the doublers while these are glued and pinned in position and then remove them and wipe them clean of glue. Commence the assembly of the fuselage by fitting the two main formers immediately fore and aft of the wing location, concentrating on getting them truly square with the sides. If it is possible to pin the fuselage to the building board, upright or inverted, during this operation, it will ensure that nothing moves until the glue has set. Temporarily pin or clamp the rear

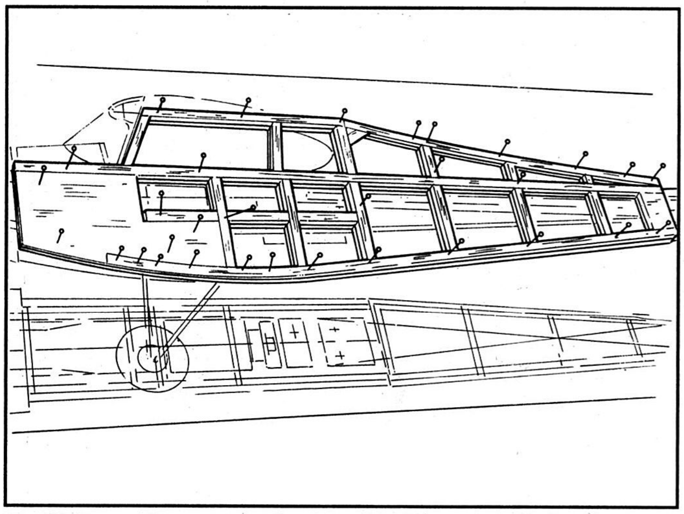


Fig. 33. Above: There are two fuselage sides here, one built directly above the other and separated by clear plastic film (you can use the domestic type or backing plastic from film covering materials).

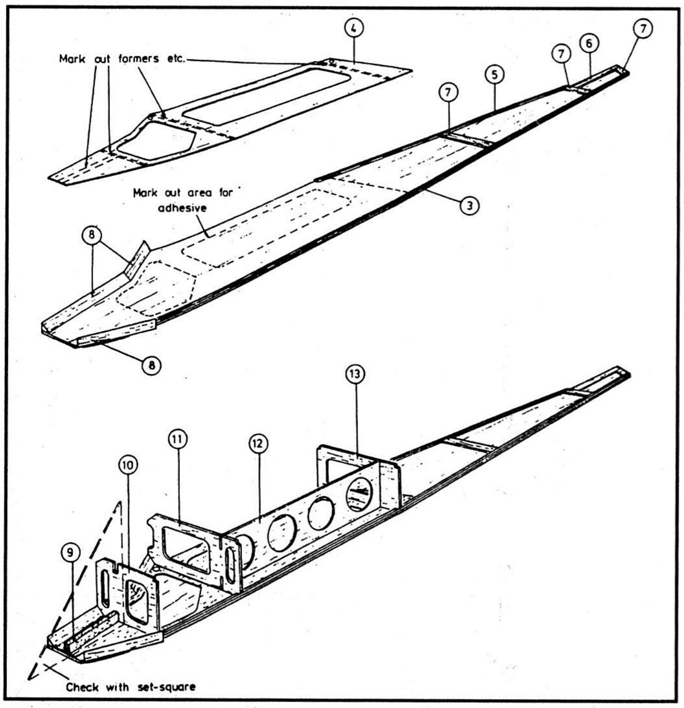


Fig. 34. Above: Sheet structure fuselages will also require reinforcement in the from of stringers, uprights and traingular section balsawood. These excellent, stage-by-stage illustrations come from a Mole Technology instruction sheet.

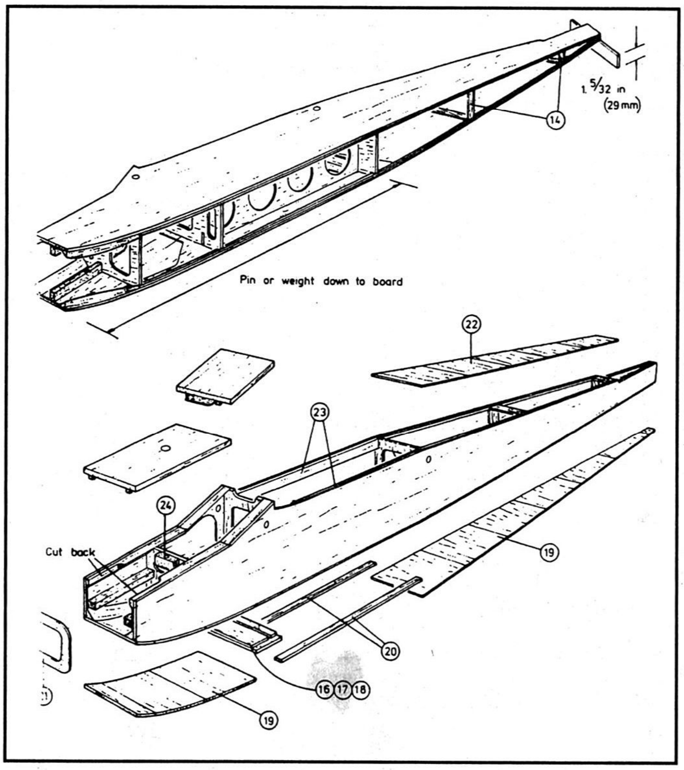


Fig. 35. Above: Basic fuselage construction continues with the adding of the second side to the three main formers, followed by rear crosspieces and joining the fuselage rear ends. Top and lower sheeting (grain across the fuselage) is added to complete a strong box structure.

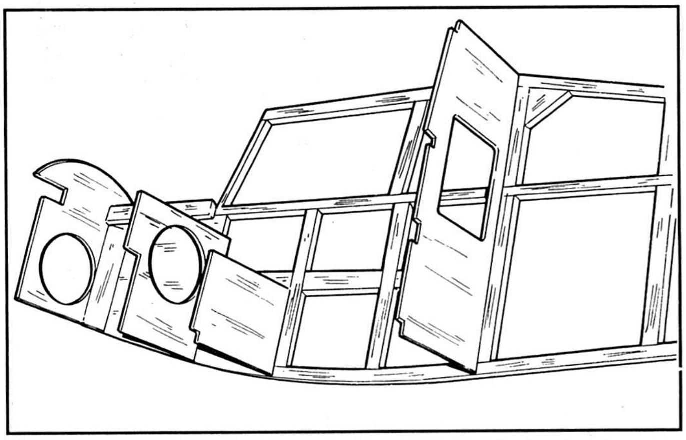


Fig. 36. **Above: Formers (at the parallel width area of the fuselage) are added to one fuselage side frame – check for 90° angle.**

ends of the fuselage together as a check to alignment. Do not be tempted to use a fast setting glue for this stage as you may have to make adjustments, pinning and securing, until you are completely satisfied that everything is as it should be, all square and symmetrical.

Contrine with the assembly by adding the engine bulkhead and remaining formers, checking for 'squareness' at all stages. Marking vertical centre lines on all formers and 'eyeing' them for correct alignment from the front and rear of the fuselage will assist in obtaining equal curvature on fuselage sides. Top and bottom sheeting is applied with the train of the balsa across the fuselage for maximum strength. Place the

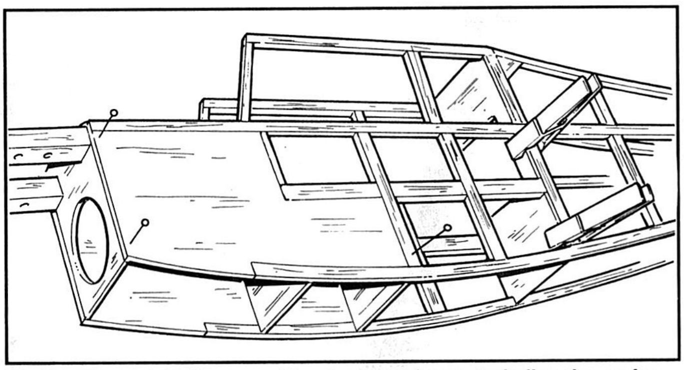


Fig. 37. Above: Add the second fuselage side frame, including the engine bearers. Use slow drying adhesive and check for 'squareness' throughout.

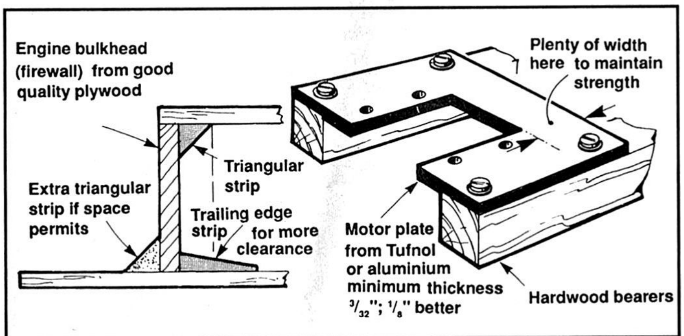


Fig. 38. Above: Engine bulkhead (front former) should be reinforced in the corners. Using a Tufnol and Paxolin engine plate gives a greater variety for engine mounting.

sheet onto the fuselage and mark on either side with a pen, cut accurately to minimise the risk of the end grain of the balsa wood being damaged during sanding. The importance of producing a true fuselage assembly cannot be over-emphasises as, without it, the overall correct alignment of the model is impossible and the flying qualities will suffer accordingly.

Certain areas are bound to be highly stressed in the fuselage, e.g. engine bulkhead and undercarriage fixing plate, and if you have any doubts about the inherent strength of the joints, they can be reinforced by applying strips of glass fibre cloth and resin to the internal corners. Do not overdo this 'beefing-up' otherwise the weight increase will be prohibitive. Holes for engine mounts and undercarriage retainers must be accurately drilled – use a centre punch for initial marking – and the method of securing these items must be determined. Wood screws are only suitable if they have a reasonable thickness of plywood, or hardwood, to screw into. Where thinner grades of plywood are specified, nuts, bolts and washers will provide better security and allow numerous removals and refixing without affecting the safety. It is not always possible, once the structure is completed, to obtain access to the bolt heads or nuts and, in these instances, some form of anchor nuts must be used. Large diameter washers should be fitted wherever possible to spread the load over the plywood.

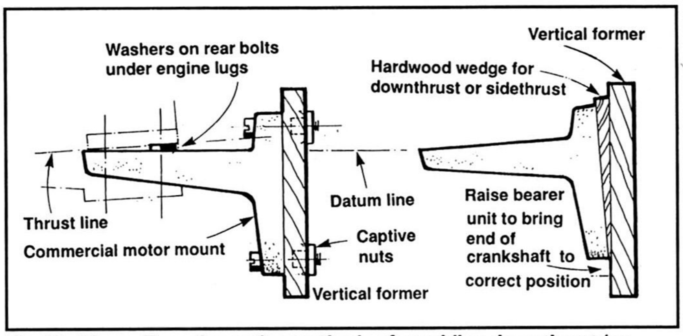


Fig. 39. Above: Two alternative methods of providing downthrust (or sidethrust) with a commercial motor mount.

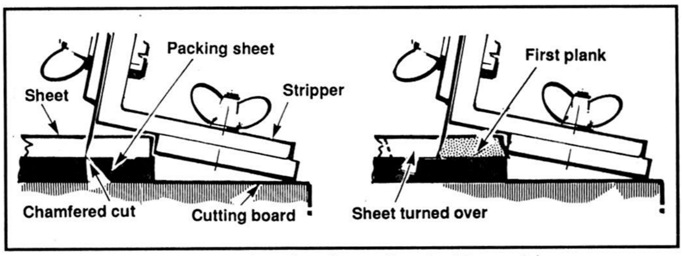


Fig. 40. Above: Producing chamfered cuts for planking strips.

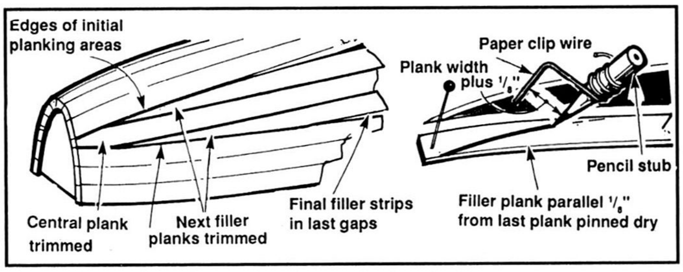


Fig. 41. Above: Marking and cutting strips for planking.

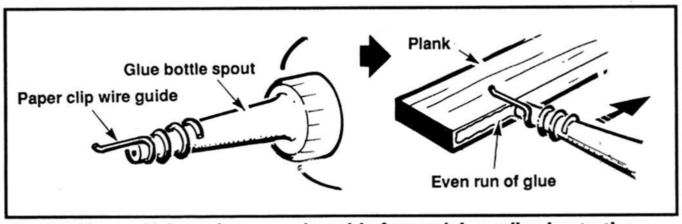


Fig. 42. Above: Using a homemade guide for applying adhesive to the edges of planking.

Marking and drilling nylon, glass-filled nylon and metal engine mounts causes a certain amount of distress to beginners – and to more experienced modellers (too many engines have been held on by only three bolts!). The engine should be positioned as far rearwards in the mount as permitted by bolt heads, flanges etc., to reduce the vibration effects when the engine is running. Marking the centre of the mounting hole positions in the engine lugs is frequently complicated by the exhaust outlet projecting beyond the holes, making it impossible to mark directly down on to the engine mount. Try this method as an alternative.

Check the position of the engine in the mount, filing away the inside of the mount flanges if necessary, and apply masking tape to the mounting surface of the flanges. Paint the underside of the engine mounting lugs with a dark coloured enamel and carefully position the engine in the mount, pressing down firmly. Remove the engine vertically and you should be left with a paint impression on the tape; punch holes in he centre of the hole positions, peel away the tape and drill. With metal engine mounts, and some of the reinforced nylon mounts, the mount can be drilled and tapped to receive bolts (use a locking washer between the bolthead and the engine lug). Small engines – up to .25cu.in capacity – can be fixed to nylon engine mounts with self-tapping screws. Using the correct size drill for forming holes

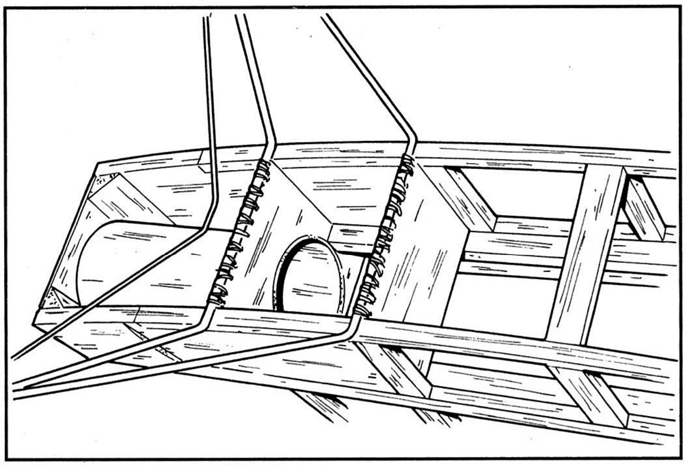


Fig. 43. Above: Bonding and gluing (slow drying epoxy) may seem to be an old fashioned means of attaching piano wire to the fuselage frame, however it remains one of the neatest and strongest.

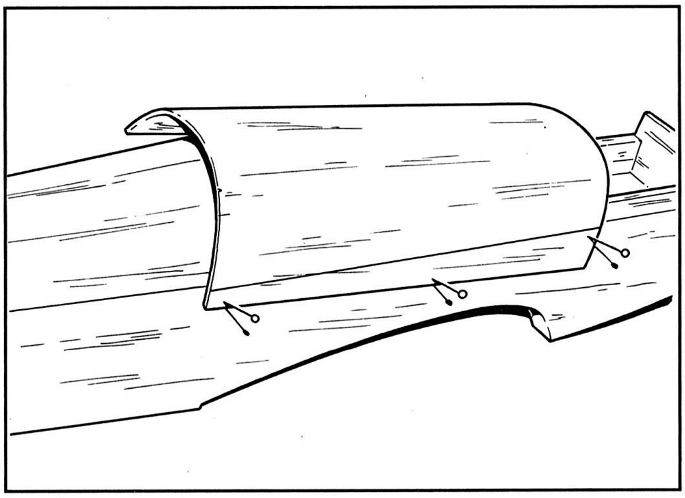


Fig. 44. Above: Use a flexible balsa for sheet coaming and soak with ammonia to improve the bending qualities if necessary. Mark for the cuts of the coaming.

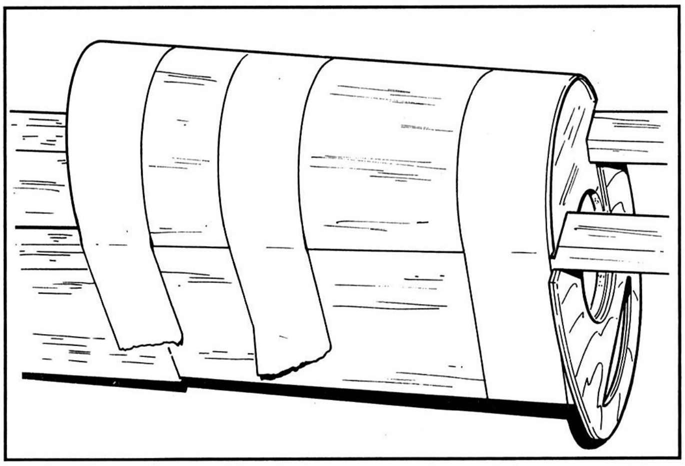


Fig. 45. Above: Use a white glue for attaching large sheet surfaces (or an aliphatic adhesive – they sand better). Hold down with masking tape, rubber bands or whatever is to hand.

for tapping or self-tap screws is all-important – countersink the beginning of the hole to prevent surplus material being forced above the level of the mounting surface.

Pre-drilling servo bearers, and building them in during the assembly process, is equally important – it is very difficult to get a drill into the fuselage after completion. Beech is far superior to spruce or remain for bearers; it is a tough, close-grained wood that accepts small wood screws without splitting. Don't forget to form cut-outs, well smoothed, in the bearers for servo lead clearance, or to allow for the fitting of the throttle linkage tube.

Undercarriage noselegs are not difficult to fit, since most moulded engine mounts make provision for clamping the top of the leg and one further saddle completes the fixing. Provision should be made for removing the noseleg in the event of damage, so consider this if you are cowling in the nose area. The same consideration is necessary for the main undercarriage fixing; the undercarriage is bound to get a fair pounding, and the strength of the fixings and accessibility is all-important. A common mistake by beginners it to mount the noseleg 'back to front' – the coil springs should always be at the rear of the leg.

Training models, and many sports models, feature wings and the tailplane held on to the fuselage by rubber bands retained by dowels.

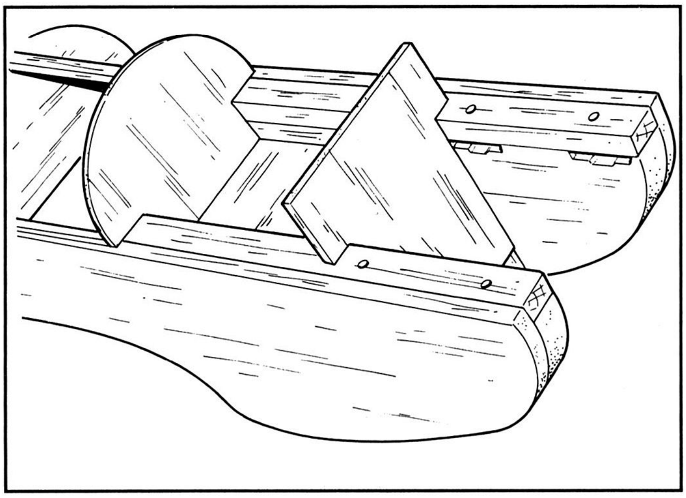


Fig. 46. Above: Note the cut-out in the under-bearer doublers for the anchor nuts to secure the bolts holding the engine plate). Corners are only rounded after all the sheet and block has been added.

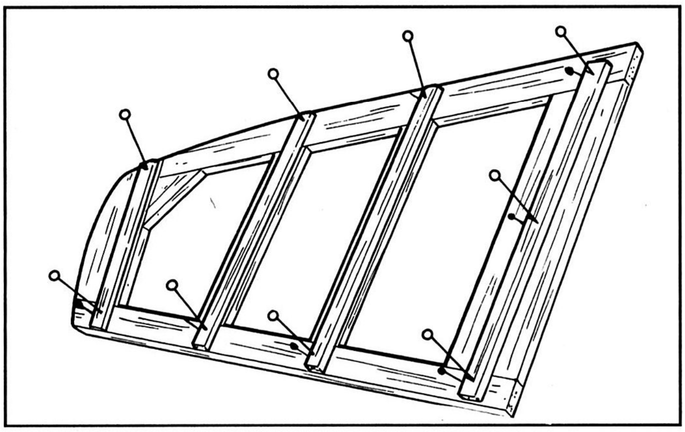


Fig. 47. Above: Simple built-up fin is further strengthened by adding horizontal strips either side of the crossmembers, base and tip.

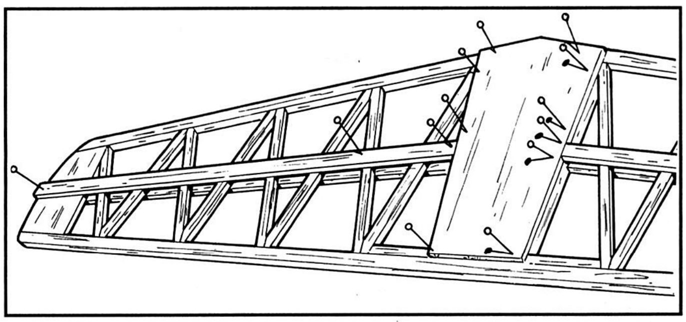


Fig. 48. Above: An early form of tailplane construction, but one that has hardly been bettered for strength and low weight. Strong covering i.e. nylon and dope, further adds to the strength.

Because of the width of the fuselage, it is not possible to drill the holes into one side of the fuselage and out the other; drilling must be done from each side. Easier still, drill the holes before assembling the fuselage. Fitting the dowels at the assembly stage, before the top and bottom sheeting is applied, ensures that the position and alignment is correct but it makes the sanding of the fuselage, and covering, hard going. Make a cardboard template of part of the fuselage side, with dowel hole centres indicated, and use this for marking the dowel positions after sanding the sides.

Tail surfaces

If the plan of the model shows tail surfaces with built up construction, there is a good reason for it – to keep the weight to a minimum at

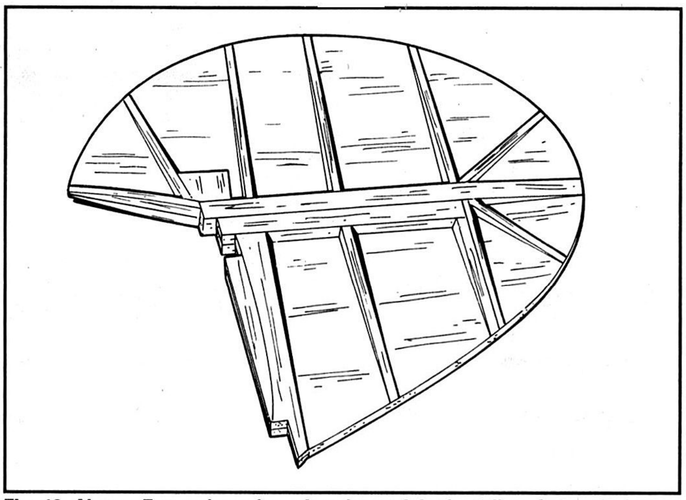


Fig. 49. Above: For scale and semi-scale models the tail surfaces can be constructed with a central core of thin sheet balsa and ribs and posts added in the form of strip.

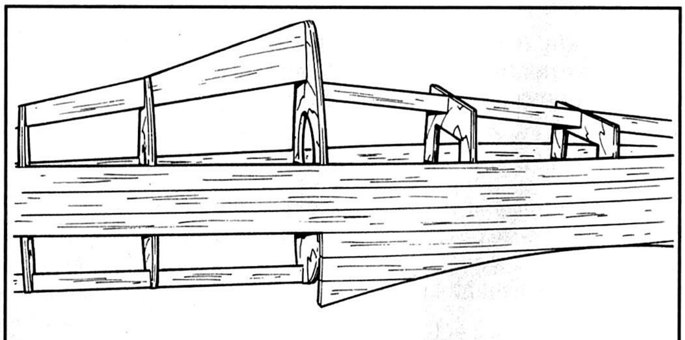


Fig. 50. Above: Irregular rounded fuselages are built with a central keel formers and strip planking.

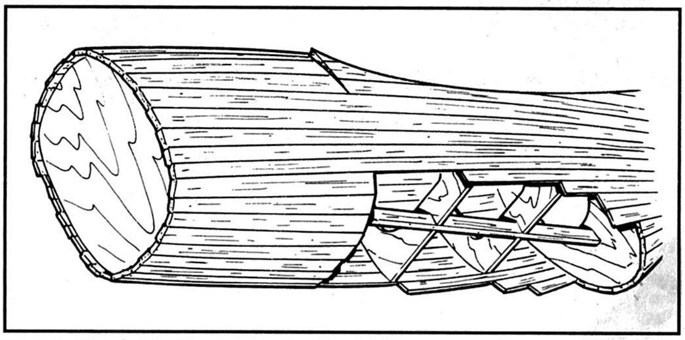


Fig. 51. Above Planking is attached to the formers working equally on either side of the fuselage centre. Each strip is cut to match the previous strip.

the tail end. To substitute sheet surfaces will almost certainly in a tail-heavy model and the need for compensating weight fixed to the nose. A model is far more likely to end up with a rearward balance point than vice-versa, the moment arm differentials see to that. Where sheeted, or solid sheet, tailplane, rudder and fin are specified, choose your balsa carefully and select a grade that is light but not soft. A composite sheet tailplane construction, using hard strip leading and trailing edge members and sheet tips, with a soft balsa centre, is probably ideal. Elevators and rudders are frequently tapered and the edges rounded off. A rounded trailing edge on a control surface is not good aerodynamic practice and the edges should be left 'square', although they can still be tapered.

Regardless of the covering and finish to be applied to the model, the airframe must be sanded to a fine smooth finish. Sanding blocks – glasspaper of various grades glued to softwood blocks – should be used and not a piece of glasspaper held in the hand. The latter will only result in the soft areas being sanded away, leaving the hard surface as high points. Garnet paper, or a similar tough abrasive sheet material, will last much longer than common glasspaper and minimise the irksome task of recovering the block. Sand the airframe components over a sheet of dense foam sponge plastic or rubber to prevent 'dings' in the balsa wood surface and to trap some of the dust particles.

So how do we alter roll with yaw? The solution is easy, change the dihedral angle but, in practical terms, not so easy. The angle will be different for fixed undercarriage. To assess what is required the model must be flown in 'knife edge'. Firstly adjust LOW rate throw so that knife edge flight is maintained without climbing.

Repeat for left rudder. You will find much more left rudder is required than right. Adjust this using the ATV with rate switch set to low. This difference is caused by the engine side thrust.

(i) *Roll with yaw*

With just rudder applied in knife edge flight note what the model does. It will normally pitch down and roll on its back or upright. Dealing with the roll first. If model rolls onto its back, the dihedral should be increased. If it rolls back upright the dihedral should be reduced. On shoulder and high wing models this can mean ANHEDRAL is required. This must be sorted before going any further, so it's back home and with a foam wing, cutting through top skin altering the dihedral and re-gluing. I would recommend altering in increments of 1/2in minimum. It may involve cutting the wing two or three times before the correct dihedral angle is found.

It should not be possible to fly the model in knife edge for at least 300 yards with just rudder applied before any roll is apparent.

Note: It may be necessary to hold slight up or down elevator to prove this.

(ii) *Pitch with yaw*

The problem of pitch change when a model is flown in knife edge is not so easy to solve. This is because the design of the model plays an important part but it is equally important that little OR NO pitch change occurs when rudder is applied.

Generally models pitch down when rudder is applied in knife edge. This can be reduced by firstly moving the centre of gravity further forward but here's the 'balloon' again. If you remember back to pitch trim, a rearward centre of gravity is desirable and directly conflicts with this. Again a compromise has to be found. Other ways of curing the pitch change are, increase tailplane area (I use 25% of wing area). Reduce fuselage area under tailplane by moving tailplane to a lower position. Increase rudder area at the top of the fin by fitting a 'balanced' rudder. Fitting a tailplane with anhedral. By increasing the anhedral, more up pitch is applied when the model is yawed. Finally, if the wing has a section in which the maximum thickness is well forward i.e. 20-25% replaces with section nearer 33-35%.

So you can see the 'design' is going to affect this trimming problem more than any other. The main reason for this down pitching appears to be when in knife edge, the wing is not lifting and down wash from the wing is lost. This causes airflow to hit the tailplane at an angle which makes the tailplane lift and hence pitch down. Normally this can be trimmed out providing the design is sound.

Low rate rudder is used during this trimming so that high rate can be switched in for spins and snaprolls. If your radio set has auto rudder then this would be used.

This gives low rate at high throttle for rolls and knife edge. When low throttle is used high rate rudder comes in automatically. This gives the extra throw required for spins, stall turns and snap rolls.

Whole on special features of radios, some sets have a programmable mixer. This allows inter mixing from any one channel to another. If rudder is selected as the 'master' channel and elevator as the 'slave' channel, any pitch change with yaw can be eliminated.

Prior to the latest 'all singing and dancing' radios trimming was a long and laborious task. Now at least it is reduced to weeks rather than months.

Conclusion

During this article I have discussed some of the problems in obtaining 'purity' of control. A model which rolls, yaws and pitches with little interaction is a joy to fly. The controls should have the same 'feel', not great differences in response between elevator, ailerons and rudder.

To achieve this is not easy but it can transform a model from a family saloon into a Formula One racing car in terms of handling.

It is unlikely that you can carry out each stage without affecting another facet of the model trim. It should be looked on as a 'moulding' process in which you improve, recheck, improve and recheck each stage. This will gradually move you towards the best compromise for your model. The advice given is the result of many years of practical trimming experience. I do not profess to be a theorest, but prefer to know it works and I hope it will work for you too.